

suggest that it would be well worth looking for such connections.

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Renewable fuels

Harnessing hydrogen

Esteban Chornet and Stefan Czernik

Biomass can produce clean fuels and could be a vital, renewable energy source for the future. The demonstration of hydrogen production from biomass-derived molecules marks progress towards this goal.

Fossil-fuel stocks are a limited resource and, as the world's governments struggle to agree on a strategy to combat pollution and greenhouse-gas emissions, the search for clean, renewable energy sources has never been more intense. On page 964 of this issue, Cortright *et al.*¹ provide experimental evidence that simple biomass-derived molecules, such as glucose and glycerol, can be treated to produce hydrogen with reasonable efficiency. The authors suggest that, with some additional effort, their technique could also be technologically and commercially viable.

Cortright *et al.* demonstrate that glucose (the sugar used as an energy source in both

plants and animals) and glycerol (derived from fats) can be reformed in the aqueous phase in the presence of a platinum-based catalyst to produce H₂. The conversion takes place at moderate temperatures, around 225–265 °C, and at pressures of 27–54 bar — conditions that prevent steam formation and ensure that the reaction sequence takes place in the aqueous phase.

The authors propose that the mechanism of hydrogen production involves the rupture and rearrangement of the biomolecules' C–C and C–O bonds on the platinum catalyst, leading to the formation of intermediates. These can then produce H₂ by reacting with the abundant water present —

glucose was used at a water–carbon molar ratio of 165, but the authors indicate that ratios as low as 15 are possible. Simple hydrocarbons and carbon dioxide are also formed. The amount of gaseous H₂ produced as a proportion of the reaction products ranges from 36–50% for glucose to 51–75% for glycerol; and carbon conversion to gaseous products is 50–84% for glucose and 83–99% for glycerol. A yield of up to 80 g of H₂ per kilogram of catalyst per hour is possible.

Cortright *et al.* claim that their approach represents a significant departure from traditional high-temperature, steam-reforming technologies. Even though these can be carried out at atmospheric pressure, they require temperatures of around 800 °C to be effective with steam–carbon molar ratios typically of 5 and even lower². Alcohols offer a lower-temperature option; vapour-phase steam reforming of those can be effectively carried out at temperatures of around 300 °C (ref. 3).

But does the proof of concept reported by Cortright *et al.*¹ hold the promise of an aqueous-phase technology for producing H₂ fuel from renewable biomass? To answer that question requires an interlinking of science, engineering and the economics of H₂ production.

Today's benchmark in H₂ production is provided by catalytic steam-reforming technology that uses simple hydrocarbons (such as methane and liquid petroleum gases) as feedstocks, and catalysts that are variations of well established nickel-based preparations and whose robustness guarantees operation over thousands of hours. The

Oceanography

Crossing the highway

The powerful current of the Gulf Stream is like a highway, carrying warm tropical waters from the Caribbean to Europe. The current is known to meander and to shed rotating rings of water on both sides. However, its interaction with the surrounding water tends to be

limited to the outer edges of the current, especially along the well defined northern wall of the Gulf Stream.

But satellite images presented by Xiaofeng Li and his colleagues in *Geophysical Research Letters* show a parcel of cold water from a region

known as the Middle Atlantic Bight breaching the northern boundary of the Gulf Stream, and traversing the full width of the current (*Geophys. Res. Lett.* **29**, 10.1029/2002GL015378; 2002).

The left panel of the picture, taken at 7:08 a.m. on 3 October 2001, shows the penetration of cold water as a green tongue that extends into the main current just east of Cape Hatteras, where the Gulf Stream leaves the American East Coast and veers off into the North Atlantic Ocean. The right panel shows the fate of the intrusion about 24 hours later: the cold tongue has been swept along with the current while extending southeastwards.

In early October 2001, strong and persistent winds from northerly directions blowing along the shore

north of Cape Hatteras piled up cold water from the Middle Atlantic Bight in the corner formed by the coastline and the Gulf Stream's north wall. Under less extraordinary wind conditions, long streaks of the relatively cold shelf water are slowly mixed into the Gulf Stream along its northwestern edge. But after three days of wind speeds exceeding 12.8 m s^{−1} — conditions unique for early autumn in the 11-year period from 1991 to 2001 — the cold coastal water broke into the main Gulf Stream and eventually crossed it.

Li and colleagues say they are not aware of any other reports of such a breaching event. After all, crossing a busy highway is rarely attempted and is even less often successful.

Heike Langenberg

